

# Stripping foil

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## 1 Model

The model includes a stripping foil and quadrupole. The code that describes the Main Ring quadrupole is not currently available. A model of quadrupole of the type 4Q120 was used instead.

For this geometry, radiation fields in the quadrupole are produced by strong interactions of protons in the carbon foil. Therefore all  $H^-$  are replaced with protons for the sake of simplicity. The total beam intensity is  $1.5 \times 10^{14} \text{ p/cycle} / 1.5 \text{ sec} \times 6 = 6 \times 10^{14} \text{ p/sec}$ , where 6 is an averaged number of proton passes through the foil. Kinetic energy of the beam is 8 GeV. The beam has a 2-D Gaussian space distribution with  $\sigma_x = 0.05 \text{ cm}$  and  $\sigma_y = 0.1 \text{ cm}$  centered at  $X_0 = 0.0 \text{ cm}$  and  $Y_0 = 2.4 \text{ cm}$ . Elevation angle of the beam is 1 mrad. The foil is  $500 \mu\text{g}/\text{cm}^2$  thick.

Elevation view of the system and quadrupole cross-section are shown in figs. 1 and 2. In fig. 2 the vertical axis goes to the right.

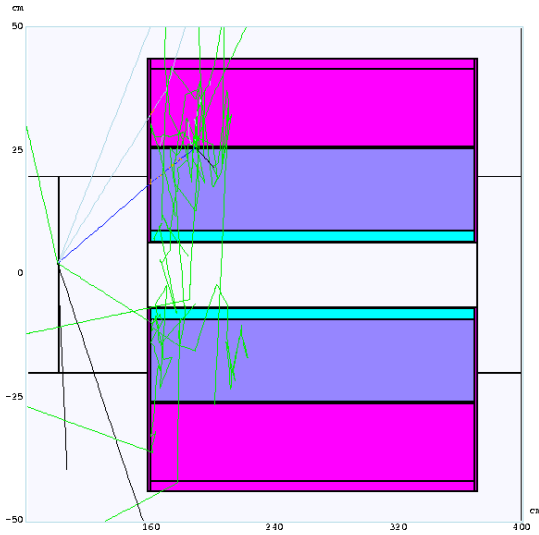


Figure 1: Elevation view.

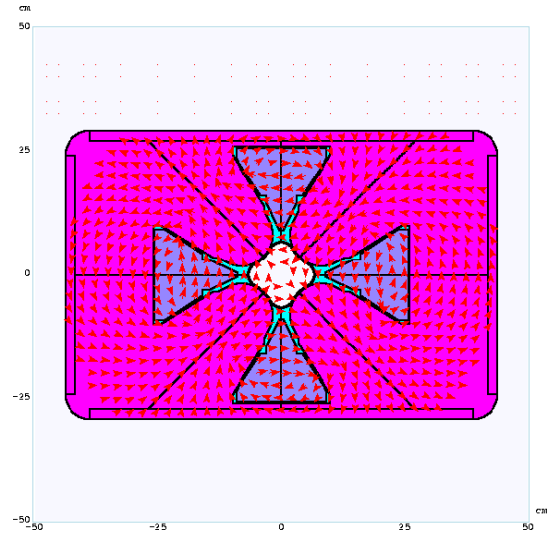


Figure 2: Quadrupole cross-section.

## 2 Residual Activation

Fig. 3 shows an azimuthally averaged histogram for residual dose on-contact after 30 days of irradiation and 1 day of cooling. Since our system is not azimuthally symmetric and the energy deposition in the quadrupole is not symmetric also, this histogram can only be used as a guidance. Also, only bins on surface make sense. Bin values vary from  $\approx 19$  mSv/hr down to 0.1 mSv/hr on the front surface of the quadrupole (remember that 1 mSv = 100 mrem). A person working in the proximity of the magnet would be exposed to radiation emitted from an extended area. Therefore, an averaged residual dose is useful to know. Table 2 summarizes the averaged residual doses on the quadrupole surface.

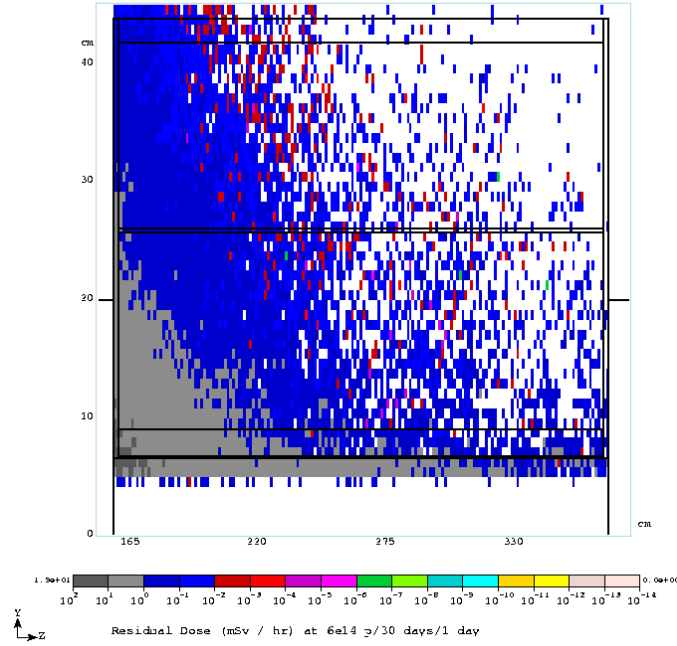


Figure 3: Azimuthally averaged plot for residual activation in quadrupole.

Table 1: Residual doses on quadrupole surface.

Surface	Residual Dose (mrem/hr)
front	$70.27 \pm 3.36$
rear	$2.82 \pm 0.77$
left	$5.88 \pm 0.57$
right	$6.03 \pm 0.62$
bottom	$2.93 \pm 0.43$
top	$3.70 \pm 0.54$

### 3 Radiation Damage to Quadrupole Coils

Insulation and epoxy is damaged by radiation. A typical limit for magnet lifetime is 400 Mrad. Absorbed doses in coil segments (as shown in fig. 2) are given in table 3. Conversion from the units GeV/g to krad/yr is defined by the following formulae.

$$Dose(krad/yr) = EnergyDeposited(GeV/g) * I(proton/sec) * 1.6e-5 * 1.0e-3 * (2.0e7sec/yr). \quad (1)$$

A 'standard' Fermilab year is  $2.0e7$  sec.

Fig. 4 shows the absorbed dose in first 50 cm of quadrupole (place of maximal energy deposition). The units on the plot are Gy/year.  $1 \text{ Gy} = 100 \text{ rad}$ .

Table 2: Absorbed dose in quadrupole coil.

Coil segment	Absorbed Dose (GeV/g)	Absorbed Dose (krad/yr)
1	$(3.28 \pm 0.26) \times 10^{-12}$	$630 \pm 50$
2	$(2.35 \pm 0.19) \times 10^{-12}$	$452 \pm 37$
3	$(2.92 \pm 0.21) \times 10^{-12}$	$560 \pm 41$
4	$(4.01 \pm 0.31) \times 10^{-12}$	$770 \pm 59$
5	$(2.72 \pm 0.20) \times 10^{-12}$	$522 \pm 39$
6	$(3.61 \pm 0.26) \times 10^{-12}$	$694 \pm 50$
7	$(2.69 \pm 0.24) \times 10^{-12}$	$517 \pm 47$
8	$(2.38 \pm 0.21) \times 10^{-12}$	$456 \pm 40$

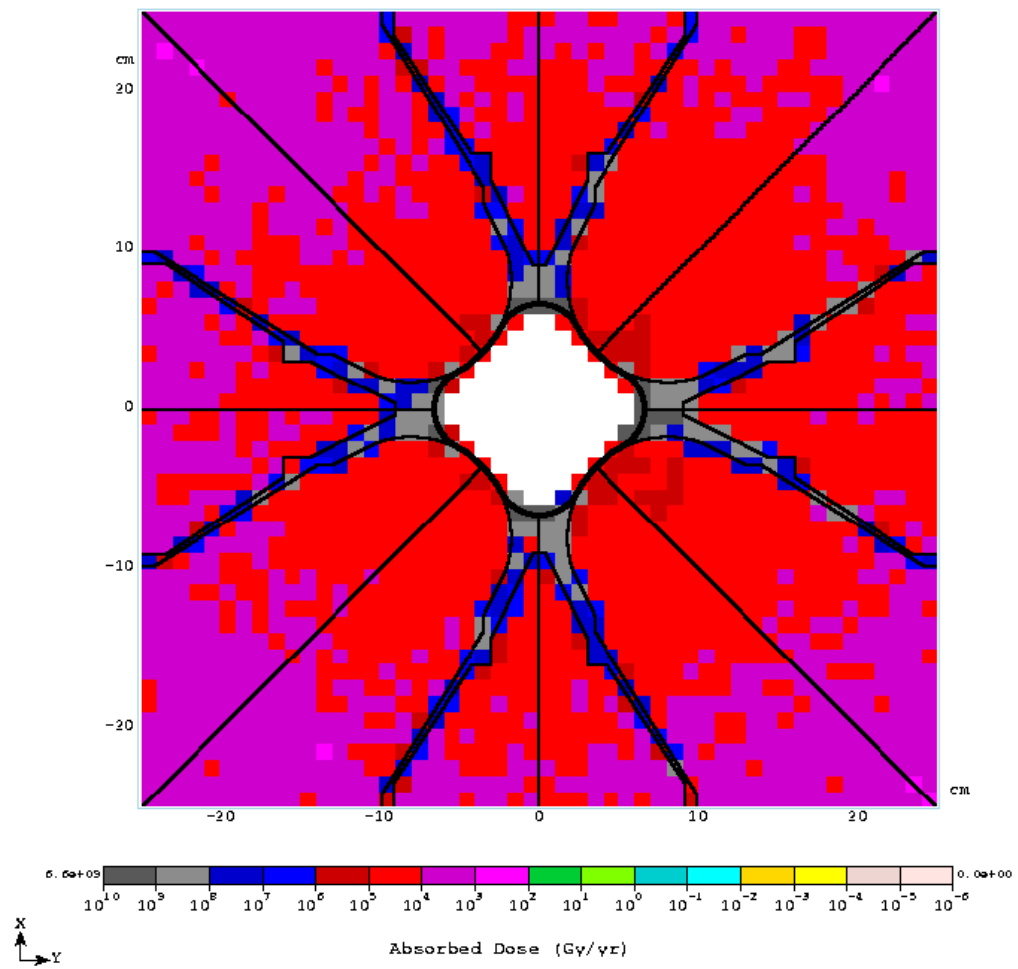


Figure 4: Absorbed Dose in first 0.5 m of quadrupole.

## 4 Energy Deposition in Carbon Foil

Instant energy deposition in the foil is assumed for energy deposition calculations. This means that the beam intensity must be increased by a factor 1.5 (one cycle). That makes  $9 \times 10^{14}$  protons/instance. Beam paining is not simulated right now. Used beam parameters are as described above. This means that the results could only be used with great care. The results are very conservative. A more sophisticated model is needed for these calculations. Fig. 5 shows a plot with the energy deposited in the foil.

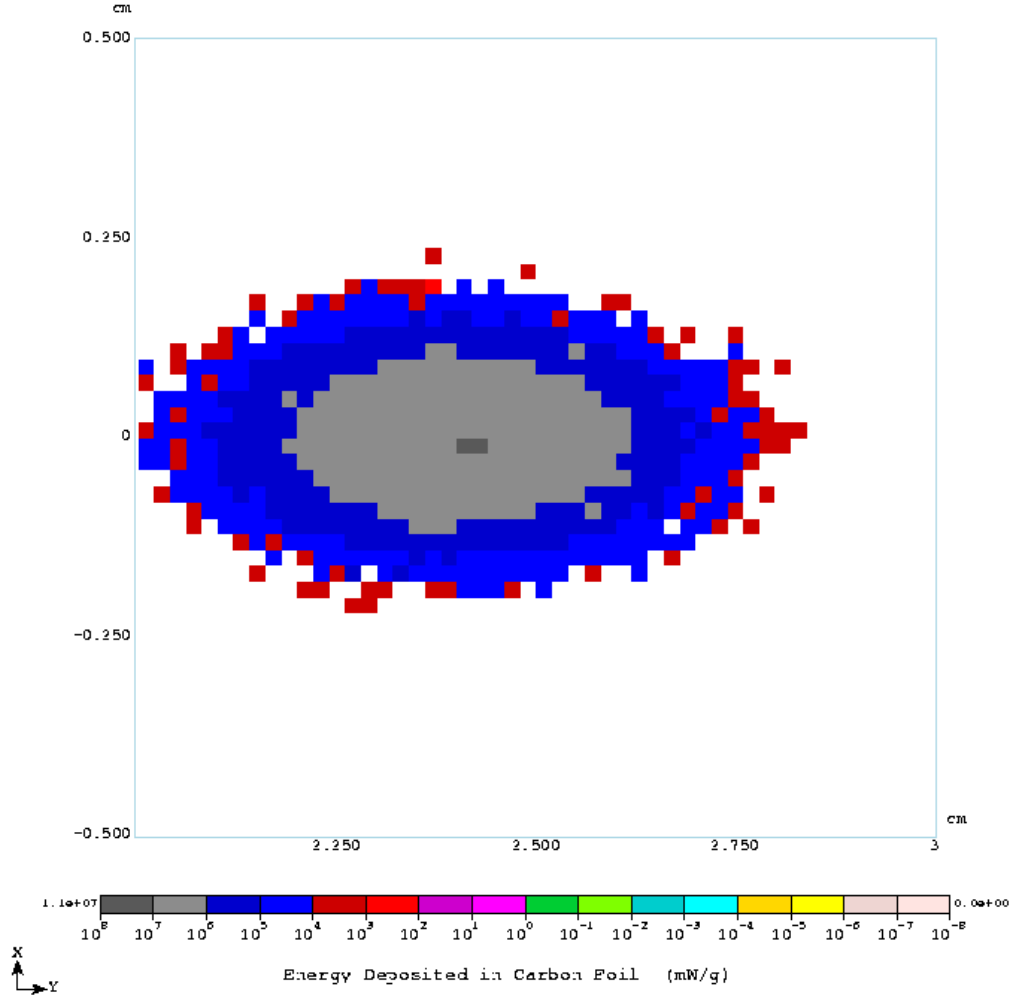


Figure 5: Energy deposited in carbon foil.